

# **Effect of Energy Development and Human Activity on the Use of Sand Sagebrush Habitat by Lesser Prairie-Chickens in Southwestern Kansas**

Robert J. Robel, Division of Biology, Kansas State University, Manhattan

John A. Harrington, Jr., Department of Geography, Kansas State University, Manhattan

Christian A. Hagen, Division of Biology, Kansas State University, Manhattan

James C. Pitman, Division of Biology, Kansas State University, Manhattan

Ryan R. Reker, Department of Geography, Kansas State University, Manhattan

Lesser prairie-chickens (*Tympanuchus pallidicinctus*) occupy xeric grasslands dominated primarily by sand sagebrush (*Artemisia filifolia*) or shinnery oak (*Quercus havardii*) in portions of southwestern Kansas, southeastern Colorado, western Oklahoma, northern Texas, and eastern New Mexico (Giesen 1998) and their populations have declined range-wide since the 1800s (Braun et al. 1994). In southwestern Kansas, lesser prairie-chickens are most abundant in mixed- and short-grass prairies dominated by sand sagebrush south of the Arkansas River. Population indices (lek counts) suggest lesser prairie-chicken numbers have declined since the 1970s (Jensen et al. 2000). Generally the decline has been attributed to the deterioration of the sandsage habitat and the conversion of suitable habitat to intensive agriculture, primarily center-pivot irrigated corn. Even though most of the large-scale conversion of sand sagebrush prairie to intensive agriculture ceased in the mid 1980s, lek indices to lesser prairie-chicken populations continued to decline in southwestern Kansas (Jensen et al. 2000).

A 6-year study initiated in 1997 examined factors that may have contributed to the 1980-2000 decline in numbers of lesser prairie-chickens in southwestern Kansas. Low nest success and poor chick survival were determined to be the most important factors contributing to the decline (Hagen 2003, Pitman 2003). The research was conducted in Finney County, an area of southwestern Kansas that historically supported a viable lesser prairie-chicken population. Lek survey indices to prairie chicken populations in that county averaged 12.1 birds per square mile (4.7 birds/km<sup>2</sup>) during the late 1960s (Church 1987). Between 1960 and 1975, approximately 60% of the native sand sagebrush prairie in Finney County was converted to intensive agriculture (Sexson 1980). That loss of habitat originally was thought to be the sole cause of the 33% decline (12.1 to 8.1 birds per square mile; 4.7 to 3.1 birds/km<sup>2</sup>) in the lesser prairie-chicken lek survey indices in Finney County during the 1980s and the 50% decrease (8.1 to 4.1 birds per square mile; 3.1 to 1.6 birds/km<sup>2</sup>) in the 1990s. However, these declines occurred even though large expanses of sand sagebrush prairie existed in the county through the 1980s and 1990s. During Hagen's (2003) and Pitman's (2003) studies, radio telemetry data disclosed avoidance by lesser prairie-chickens of what appeared to be suitable sand sagebrush habitat near anthropogenic features, e.g., roads, buildings, oil and gas wellheads, electric transmission lines, and center-pivot irrigation fields.

The human population of Finney County increased by over 25% between 1980 and 2000 (U. S. Census Bureau 2003), coincidental with the construction of a coal-fired electric generating station and associated transmission lines, road improvements, and an increased number of houses in rural settings. Petroleum exploration and production also increased in the county and compressor stations were constructed to move natural gas through underground pipelines. These anthropogenic changes in Finney County coincided with declines in lek survey indices to lesser prairie chicken populations in the 1980s and 1990s.

We conducted this study to assess the magnitude of the impacts of anthropogenic factors on use of sand sagebrush habitat by lesser prairie-chickens. We focused our efforts on the remaining sand sagebrush habitat in Finney, Kearny, and Hamilton counties of southwestern Kansas, the three counties supporting 25 to 50% of the lesser prairie-chicken population in Kansas during the early 2000s (assuming lek survey data are a realistic reflection of lesser prairie-chicken numbers).

## **Methods and Procedures**

Data used to determine use of sand sagebrush habitat by lesser prairie-chickens were obtained from transmitter-equipped birds on two 12,500 acre (5,070 ha) study sites in Finney County during a 1997-2003 field study. Lesser prairie-chickens were captured on leks using walk-in funnel traps (Haukos et al. 1990) primarily during March and April. Captured birds were fitted with < 0.4-ounce transmitters (< 2% of each bird's body mass) and released within 15 minutes at capture sites. Birds were located daily by triangulation using a truck-mounted null-peak twin-Yagi telemetry system. The influence of anthropogenic features on the use of sand sagebrush habitat was estimated from these data, and its impact was extrapolated to the remaining sand sagebrush habitat in Finney, Kearny, and Hamilton counties during 2003-2004.

### Study Area

The sand sagebrush prairies of Finney, Kearny, and Hamilton counties exist primarily on undulating sand dunes south of the Arkansas River (Kuchler 1974). Two soil types are typical across the sand sagebrush vegetation complexes, Tivoli fine sand and Tivoli-Vona loamy fine sands (Harner et al. 1965). The long-term average annual precipitation for the area was 19 inches with 75% of it occurring between March and August; the mean annual temperature was 55°F, ranging from 21°F for January to 79°F for July (U. S. Department of Commerce 2003).

Sand sagebrush dominated the vegetative community and was interspersed with grasses including six-week fescue (*Vulpia octoflora*), blue grama (*Bouteloua gracilis*), sand dropseed (*Sporobolus cryptandrus*), prairie sandreed (*Calamovilfa longifolia*), sand bluestem (*Andropogon halii*), and little bluestem (*Schizachyrium scoparium*). Other plants common on the area included western ragweed (*Ambrosia psilostachya*), annual erigeron (*Erigeron annuus*), sunflowers (*Helianthus* spp.), plains yucca (*Yucca glauca*), prickly pear (*Opuntia polyacantha*), and Russian thistle (*Salsola kali*). Kuchler (1974) presents a detailed description of the vegetation of the sand sagebrush prairie of the three counties. Over 90% of the sand sagebrush rangeland was grazed annually by cattle at various intensities resulting in highly variable vegetation structure across the study area.

### Determining Coverage of Sand Sagebrush Prairie

The historical distribution of sand sagebrush habitat in Finney, Kearny, and Hamilton counties was primarily defined by the extent of the Tivoli association soil complex and vegetation based landcover maps by Kuchler (1974). Defining natural habitat based on soil types has been successfully used in similar studies (Johnson et al. 1995). Two Landsat 1 Multispectral Scanner images (pixel resolution = 66 yards) were used to identify sand sagebrush acreage in the three counties for 1973 whereas two Landsat 7 Enhanced Thematic Mapper (ETM+) images (pixel resolution = 36 yards) and ground truthing were used for 2001 determinations.

### Inventory of Anthropogenic Features in the Three Counties

Locations of anthropogenic features in the sand sagebrush habitat were entered into a GIS system for display and analysis. Road center lines from the U.S. Census Bureau were downloaded from the Kansas Data Access and Support Center. Point data for oil and oil/gas wellheads were downloaded from the Kansas Geological Survey Database. Locations of buildings (large houses, feedlots, ranch steads, compressor stations, and the power plant) were

identified on U.S. Geological Survey 1:24,000 topographic maps and Landsat satellite imagery and a polygon layer of building sites was created by digitizing feature boundaries. Paper maps of electric transmission line routes were provided by the Sunflower Electric Corporation, georeferenced to Landsat ETM+ satellite imagery, then digitized into ArcInfo 8.1 to create a transmission line layer. Center-pivot fields were identified by their distinctive spectral and textural properties and classified in ERDAS Imagine 8.7 (Leica Geosystems 2003).

The scale of satellite images and coarse pixel resolution limited our ability to identify small anthropogenic features (minor roads and trails, individual houses, trailers, and small outbuildings). Therefore, our assessment of the impacts of anthropogenic features on lesser prairie-chickens in the sand sagebrush habitat of the 3-county area must be interpreted as a conservative estimate.

#### Determining Areas Avoided by Nesting Lesser Prairie-chickens

The movements of transmitter-equipped female lesser prairie-chickens were monitored daily during April-June to locate 187 nests. From these data, Pitman (2003) determined the distances to anthropogenic features avoided by nesting lesser prairie-chickens. Lesser prairie-chicken nests were located farther from five of six features than would be expected at random. The presence of unimproved roads had the least affect on placement of nests, and buildings the greatest (Table 1).

Locations of nests were incorporated into a geographic information system of the two study areas created in ArcView 3.1 (Environmental Systems Research Institute 1998) along with locations of wellheads, buildings, transmission lines, improved and unimproved roads, and center-pivot irrigated fields. Distances from each nest to the nearest wellhead, building, transmission line, improved or unimproved road, and center-pivot irrigated field edge (hereafter center-pivot field) were calculated for each nest.

Wellheads were oil and oil/gas wells with pumping units powered primarily by diesel fuel. Buildings consisted of houses, gas compressor stations, and a 380 MW coal-fired electric generating station. Transmission lines primarily were 125, 138, and 345 kV double circuit conductors distributing electricity from the generating station. Improved roads were graveled or paved and carried up to 486 vehicles per day (vpd) whereas unimproved roads were 2-lane pasture trails and ungraded service roads to wellheads with traffic <3 vpd. Center-pivot fields covered 160 acres with a water pump in the center and a 13- to 16-foot high sprinkler boom extending from the center to the edge of the field. When in operation (generally from late April or early May through summer), the sprinkler boom irrigated the field by rotating circularly across the field on self-powered wheels.

We used Monte Carlo simulations (Manly 1998) to determine if any of the six anthropogenic features were related to distances to locations of lesser prairie-chicken nests. Because features far from nest sites were unlikely to impact nesting birds, we used only nests close to each feature (closest 10% of the nests) to assess the impacts of the six anthropogenic features. Probability distributions were used to determine if nests were significantly ( $P = 0.05$ ) farther than expected from a particular feature. If nests were significantly farther than expected from a feature, that feature was determined to negatively effect lesser prairie-chicken nest location. The mean distance of the closest 10% of the nests to a specific anthropogenic feature

was determined, and that distance was used as the ‘avoidance distance’ of nesting lesser prairie-chickens for that feature.

#### Determining Areas Avoided by Adult Lesser Prairie-chickens

We quantified use and non-use areas of sand sagebrush habitat from telemetry locations of lesser prairie-chickens. Use areas were defined using a 95% fixed kernel home range (Worton 1989) of bird locations. Because multiple locations at nest or lek sites may have underestimated the size of the kernel, we used only one lek or nest location per bird for kernel home range calculations. Sand sagebrush habitat not within the 95% fixed kernel home range was considered as the non-use area.

Vegetation measurements from 42 random locations in areas of sand sagebrush habitat used by lesser prairie-chickens (use areas) and 42 in areas not used by the birds (non-use areas) were the basis of comparing vegetation structure of use and non-use areas (Hagen 2003). Sagebrush canopy cover did not differ between use and non-use areas, nor did forb or grass canopy cover. Neither sagebrush density nor mean diameter of sagebrush plants differed between use and non-use areas. The only vegetation variable that differed between use and non-use areas was litter cover; being significantly greater on non-use than use areas. Thus, based on the vegetation measurements made, the vegetation structure of the sand sagebrush habitat in areas used and not used by adult lesser prairie-chickens was virtually identical.

Lesser prairie-chicken location data from April to September 2000 to 2002 were analyzed for impacts of four anthropogenic features (roads, buildings, wellheads, and transmission lines) on their distribution by month and year. Negative impacts of roads and wellheads were less than those of buildings and transmission lines (Table 2). These distances were used in GIS models to estimate the effects of human activity on sand sagebrush habitat use by adult lesser prairie-chickens.

#### Quantifying the Acreage Impacted by Anthropogenic Features

Distance to anthropogenic features avoided by 90% of nesting and 95% of adult lesser prairie-chickens were entered into an avoidance buffer database. Avoidance buffers around/or along individual anthropogenic features were created in ArcInfo 8.1 (Environmental Systems Research Institute 2001) with the width of avoidance determined from previously described field data. Buffers around anthropogenic features often overlapped, i.e., transmission lines running adjacent to roads, wellheads lying within center-pivot fields, and so on. This overlap could result in overestimation of avoidance area. To eliminate bias associated with overlap, the Merge and Dissolve by Attribute functions in ArcInfo 8.1 were used to create one comprehensive avoidance buffer that apportioned duplicated areas of impact among overlapping features.

### **Results and Discussion**

#### Extent of Sand Sagebrush Prairie Habitat

Historically, an estimated 339,645 acres (137,556 ha) of sand sagebrush habitat existed in Finney, Kearny, and Hamilton counties. By 1973, this acreage had been reduced to 298,806 acres (121,016 ha) primarily due to conversion of sand sagebrush habitat to center-pivot agriculture (Table 3). Another 81,994 acres (33,208 ha) of sand sagebrush habitat was lost to center-pivot agriculture between 1973 and 2001. That loss, and a commitment of 3,277 acres

(1,327 ha) to urban development (residences, golf courses, etc.) left only 214,183 acres (86,744 ha) of sand sagebrush habitat in the three counties by 2001; approximately 63% of the historical acreage. Most of the loss of sand sagebrush habitat occurred in Finney County (74,154 of 142,132 acres; 52%) and in Kearny County (48,625 of 67,321 acres; 72%), and least in Hamilton County (2,004 of 130,192 acres; 2%).

#### Nest Locations Relative to Anthropogenic Features

Lesser prairie-chicken nests were located farther from five of six anthropogenic features than would be expected at random. Essentially, the presence of anthropogenic features reduced the suitability for nesting of the surrounding sand sagebrush habitat.

We did not attempt to determine causative factors associated with nesting lesser prairie-chicken avoidance of anthropogenic features, however, it appears that movement and noise might be implicated. Wellheads had pump jacks with weighted extensions that moved up and down when pumping, with larger units on deeper wells. The sprinkler booms of center-pivot irrigation systems moved across fields when operating and water nozzles on the ends sprayed back and forth. Vehicles ranging from small sedans to large grain and tanker trucks moved along roads, and more vehicle movement occurred on improved than unimproved roads. All of the anthropogenic features were sources of noise. On calm nights, pumps of center-pivots could be heard at a distance of approximately 0.6 mile, gas compressor stations were audible at over 2 miles, and noise from the power plant could be heard from 1 to 2 miles. Low frequency sounds were audible from the electric transmission lines when high voltage charges were being moved through the lines. Truck traffic on improved roads was commonly heard at 1-1/2 miles, and farther when drivers geared the trucks down for curves or inclines.

Additional research is needed to determine why the anthropogenic features we examined deterred lesser prairie-chickens from nesting near them. Such answers may allow modification of those features to reduce their negative impacts on nest placement by lesser prairie-chickens, and possible other avian species sensitive to human activity.

#### Acreage of Avoidance Buffers Around Anthropogenic Features

The acreage of sand sagebrush habitat made less suitable for lesser prairie-chicken nesting and use by the presence of anthropogenic features is substantial. The area approaches the acreage of sand sagebrush habitat converted to center-pivot agriculture in Finney, Kearny, and Hamilton counties.

Our research, and that of Peterson and Silvy (1996) and Wisdom and Mills (1997), determined that nest success was one of the most critical demographic parameters regulating prairie grouse populations. Therefore, any negative impacts of anthropogenic features on nesting of lesser prairie-chickens is of great concern.

The presence of improved roads reduced nesting by lesser prairie-chickens in the 859-yard buffer on either side of the roads. In 1973, that buffer included 141,312 acres (57,231 ha) of sand sagebrush habitat (Table 3). That estimate may be high because not all of the roads identified on the Landsat imagery carried high volumes of traffic. However, even if only 50% of the roads carried high levels of traffic, the acreage negatively impacted would exceed 70,000 acres (28,000 ha). The amount of sand sagebrush habitat negatively impacted by roads in 2001

was less than in 1973 because the roads crossed areas that were sagebrush in 1973, but had been converted to center-pivot fields by 2001. Even so, and assuming that only 50% of the roads carried high traffic volumes, the negative impacts of roads in the three counties extended to over 40,000 acres (16,200 ha) of sand sagebrush habitat in 2001.

Oil and oil/gas wellheads negatively impacted lesser prairie-chicken nesting on an estimated 8,564 acres (3,468 ha) of sandsage habitat in 1973. This area increased to 17,562 acres (7,113 ha) by 2001.

The presence of buildings negatively impacted 8,974 acres (3,634 ha) of lesser prairie-chicken nesting habitat in 1973, and increased to 15,774 acres (6,388 ha) by 2001. Buildings included a coal-fired power electric generating station, at least three compressor stations, and numerous large houses and cattle feedlots.

There were few to no major electric transmission lines crossing the sand sagebrush habitat of Finney, Kearny, and Hamilton counties in 1973, but several lines were present in 2001. These transmission lines were distributing electricity primarily to the west and southwest of the power station 7 miles (11 km) southwest of Garden City, in Finney County. Lesser prairie-chickens seldom nested within 400 yards of the electric transmission lines. The avoidance buffer encompassed by the transmission lines in the early 2000s approximated 16,803 acres (6,805 ha) of sand sagebrush habitat (the estimate includes the impacts of a transmission line under construction in 2003).

The avoidance buffers on the edges of center-pivot fields negatively affected approximately 31,795 acres (12,472 ha) of sand sagebrush habitat in 1973, and 53,694 acres (21,746 ha) by 2001. We do not know if nesting female lesser prairie-chickens were avoiding the center-pivot fields themselves, the noise from the irrigation pump in the center of the fields, or the large sprinkler booms that rotated across the fields. What ever the reason, lesser prairie-chickens seldom nested within 336 yards of the edges of center-pivot fields.

Combined, the total avoidance buffer areas around anthropogenic features in the three counties reduced the suitability of 157,296 acres (63,705 ha) and 125,962 acres (51,015 ha) of sand sagebrush habitat for lesser prairie-chicken nesting in 1973 and 2001, respectively. These areas represent 52% of the sand sagebrush habitat remaining in the three counties in 1973, and 58% of that remaining in 2001.

The area of sand sagebrush habitat made less suitable for general use by adult lesser prairie-chickens was less than that made unsuitable for nesting. Avoidance buffers along roads encompassed 12,320 acres (4,990 ha) in 1973 and 9,739 acres (3,944 ha) in 2001. Oil and oil/gas wellheads negatively impacted 1,440 acres (583 ha) in 1973 and 3,183 acres (1,289 ha) in 2001. Avoidance buffers around buildings contained 3,034 acres (1,229 ha) in 1973, increasing to 7,399 acres (2,997 ha) by 2001. Adult lesser prairie-chicken seldom used sand sagebrush habitat within 693 yards of electric transmission lines, and that avoidance buffer area amounted to 6,615 acres (2,679 ha) in 2001. Although some of these totals appear large, their impacts on the lesser prairie-chicken population are minor compared to the impacts of the presence of anthropogenic features on nesting habitat.

### Summary and Management Implications

The decline of lesser prairie-chicken numbers in southwestern Kansas has been attributed to the loss of suitable habitat during the 1960s through the 1980s, primarily sand sagebrush prairie. However, population declines continued after large-scale losses of sand sagebrush habitat ceased and large tracts of that habitat remained. A 6-year study disclosed that low nest success was one of the most important factors in the decline of lesser prairie-chicken numbers in southwestern Kansas and that the birds avoided otherwise suitable habitat near human activity, especially for nesting. Human activity (population numbers, oil and gas development, construction of a coal-fired electric generation station, etc.) increased in southwestern Kansas coincidental with the decline of lesser prairie-chicken numbers. To gain a better understanding of the relationship between human activity and the viability of lesser prairie-chicken populations, we assessed the impacts of the presence of anthropogenic features (roads, buildings, transmission lines, etc.) on the use of sand sagebrush habitat by the birds.

The distance to anthropogenic features avoided by nesting lesser prairie-chicken females were used to create 'avoidance buffers' around anthropogenic features in sand sagebrush habitat. Sand sagebrush habitat within the avoidance buffer was less suitable for nest locations of 90% of nesting females, and for use by 95% of adult birds. The area contained in these buffer areas was then estimated for the sand sagebrush habitat remaining in Finney, Kearny, and Hamilton counties of southwestern Kansas. These three counties were thought to support a significant portion of the Kansas lesser prairie-chicken population.

By 2001, approximately 125,462 acres (50,812 ha) of the historic 339,645 acres (137,556 ha) of sand sagebrush prairie in the three counties had been converted to intensive agriculture or used for urban development. Avoidance buffers around improved roads, oil and oil/gas wellheads, buildings, electric transmission lines, and center-pivot fields reduced the nesting suitability of an additional 125,962 acres (51,015 ha) of sand sagebrush habitat. Thus, the amount of sand sagebrush habitat suitable for nesting by lesser prairie-chickens was only 88,221 acres (35,729 ha) in 2001, approximately 26% of the historic amount.

The impact of the avoidance buffers is depicted in Figure 1. The historic range of sand sagebrush habitat in Finney County (A) was reduced to 214,183 acres (86,744 ha) by 2001 (B), and that area was further reduced to only 88,221 acres (35,729 ha) of suitable nesting habitat (C) by the presence of anthropogenic features in the sand sagebrush prairie landscape. We suspect that the poor nest success and low chick survival experienced by lesser prairie-chickens in Finney County (Hagen 2003, Pitman 2003) were the result of a shortage of suitable nesting habitat. The remaining patches of sand sagebrush habitat suitable for nesting in that county were small and isolated, potentially increasing the predator pressure on lesser prairie-chicken nests, the nesting birds, and any fledgling chicks.

In the future, the negative impacts of anthropogenic features should be considered when assessing the suitability of habitat for lesser prairie-chickens, purchasing or leasing habitat for those birds, or implementing management actions for the benefit of those populations. The avoidance buffers around oil and oil/gas wellheads, electric transmission lines, and buildings must be recognized and integrated into environmental assessments of the development of petroleum resources and the construction of industrial wind energy facilities. The results of our



research most likely apply to other prairie grouse, but specific studies are needed to determine the magnitude of the impacts on individual species in various landscapes.

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**Table 1. Mean distance (yards  $\pm$  SE) to anthropogenic features avoided by 90% of 187 nesting lesser prairie-chickens during 1997-2002 in sand sagebrush prairie habitat of southwestern Kansas.**

<b>Anthropogenic feature</b>	<b>Distance to feature</b>
Oil or gas wellheads	193 $\pm$ 25
Center-pivot fields	336 $\pm$ 51
Unimproved roads	32 $\pm$ 15 <sup>a</sup>
Improved roads	859 $\pm$ 44
Buildings	1,371 $\pm$ 65
Electric transmission lines	397 $\pm$ 70

<sup>a</sup> Not significantly different ( $P > 0.05$ ) from zero; the distance was not used in estimate of less suitable sand sagebrush habitat for nesting by lesser prairie-chickens in the 3-county area.

**Table 2. Mean distance (yards  $\pm$  SE) to anthropogenic features across which 95% of 18,866 telemetry locations of lesser prairie-chickens were absent in sand sagebrush prairie habitat of southwestern Kansas.**

Anthropogenic feature	Distance to feature
Improved and unimproved roads	51 Å 4 <sup>a</sup>
Oil or gas wellheads	79 Å 5
Buildings	659 Å 46
Electric transmission lines	693 Å 44

<sup>a</sup> Not significantly different ( $P > 0.05$ ) from zero; but distance was used in estimate of less suitable sand sagebrush habitat for use by lesser prairie-chickens in the 3-county area.

**Table 3. Acreage of sand sagebrush prairie habitat converted to intensive agriculture or made less suitable as lesser prairie-chicken nesting areas by the presence of anthropogenic features in Finney, Kearny, and Hamilton counties, Kansas, in 1973 and 2001.**

	1973	2001
Historical acreage of sagebrush habitat	339,645	339,645
Converted to intensive agriculture	40,191	122,185
Converted to other uses (urban, recreation, etc.)	649	3,277
Sagebrush habitat remaining	298,806	214,183
Remaining sagebrush habitat made less suitable by presence of:		
Improved roads	141,312	89,297
Oil and oil/gas wellheads	8,564	17,562
Buildings	8,974	15,774
Electric transmission lines	nil	16,803
Center-pivot fields	30,795	53,694
Total acreage made less suitable by anthropogenic features	157,296	125,962
Remaining sagebrush habitat suitable for nesting by lesser prairie-chickens	141,570	88,221

*[Note: figure not available electronically.]*

Figure 1. Map showing changes in sand sagebrush prairie in Finney County, Kansas. A = historic coverage of sand sagebrush vegetation (black), B = sand sagebrush prairie remaining in 2001 (black), and C = sand sagebrush prairie in 2001 suitable for nesting by lesser prairie-chickens (black), and unsuitable for nesting (gray) due to presence of anthropogenic features.